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APPLICATION NO.	FILING DATE	FIRST NAMED INVENTOR	ATTORNEY DOCKET NO.	CONFIRMATION NO.
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Koichi Matsuda

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EXAMINER

GARDNER, SHANNON M

ART UNIT

PAPER NUMBER

1795

MAIL DATE

DELIVERY MODE

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PAPER

Please find below and/or attached an Office communication concerning this application or proceeding.

The time period for reply, if any, is set in the attached communication.

Office Action Summary	Application No. 10/807,103	Applicant(s) MATSUDA ET AL.	
	Examiner Shannon Gardner	Art Unit 1795	

-- The MAILING DATE of this communication appears on the cover sheet with the correspondence address --

Period for Reply

A SHORTENED STATUTORY PERIOD FOR REPLY IS SET TO EXPIRE 3 MONTH(S) OR THIRTY (30) DAYS, WHICHEVER IS LONGER, FROM THE MAILING DATE OF THIS COMMUNICATION.

- Extensions of time may be available under the provisions of 37 CFR 1.136(a). In no event, however, may a reply be timely filed after SIX (6) MONTHS from the mailing date of this communication.
- If NO period for reply is specified above, the maximum statutory period will apply and will expire SIX (6) MONTHS from the mailing date of this communication.
- Failure to reply within the set or extended period for reply will, by statute, cause the application to become ABANDONED (35 U.S.C. § 133). Any reply received by the Office later than three months after the mailing date of this communication, even if timely filed, may reduce any earned patent term adjustment. See 37 CFR 1.704(b).

Status

- 1) ☒ Responsive to communication(s) filed on 27 March 2009 (RCE).
- 2a) ☐ This action is **FINAL**. 2b) ☒ This action is non-final.
- 3) ☐ Since this application is in condition for allowance except for formal matters, prosecution as to the merits is closed in accordance with the practice under *Ex parte Quayle*, 1935 C.D. 11, 453 O.G. 213.

Disposition of Claims

- 4) ☒ Claim(s) 1-8, 12 and 13 is/are pending in the application.
- 4a) Of the above claim(s) _____ is/are withdrawn from consideration.
- 5) ☐ Claim(s) _____ is/are allowed.
- 6) ☒ Claim(s) 1-8, 12 and 13 is/are rejected.
- 7) ☐ Claim(s) _____ is/are objected to.
- 8) ☐ Claim(s) _____ are subject to restriction and/or election requirement.

Application Papers

- 9) ☐ The specification is objected to by the Examiner.
- 10) ☐ The drawing(s) filed on _____ is/are: a) ☐ accepted or b) ☐ objected to by the Examiner.
Applicant may not request that any objection to the drawing(s) be held in abeyance. See 37 CFR 1.85(a).
Replacement drawing sheet(s) including the correction is required if the drawing(s) is objected to. See 37 CFR 1.121(d).
- 11) ☐ The oath or declaration is objected to by the Examiner. Note the attached Office Action or form PTO-152.

Priority under 35 U.S.C. § 119

- 12) ☐ Acknowledgment is made of a claim for foreign priority under 35 U.S.C. § 119(a)-(d) or (f).
- a) ☐ All b) ☐ Some * c) ☐ None of:
1. ☐ Certified copies of the priority documents have been received.
 2. ☐ Certified copies of the priority documents have been received in Application No. _____.
 3. ☐ Copies of the certified copies of the priority documents have been received in this National Stage application from the International Bureau (PCT Rule 17.2(a)).

* See the attached detailed Office action for a list of the certified copies not received.

Attachment(s)

- | | |
|--|---|
| 1) <input type="checkbox"/> Notice of References Cited (PTO-892) | 4) <input type="checkbox"/> Interview Summary (PTO-413) |
| 2) <input type="checkbox"/> Notice of Draftsperson's Patent Drawing Review (PTO-948) | Paper No(s)/Mail Date. _____ |
| 3) <input type="checkbox"/> Information Disclosure Statement(s) (PTO/SB/08) | 5) <input type="checkbox"/> Notice of Informal Patent Application |
| Paper No(s)/Mail Date _____ | 6) <input type="checkbox"/> Other: _____ |

DETAILED ACTION

Continued Examination Under 37 CFR 1.114

1. A request for continued examination under 37 CFR 1.114, including the fee set forth in 37 CFR 1.17(e), was filed in this application after final rejection. Since this application is eligible for continued examination under 37 CFR 1.114, and the fee set forth in 37 CFR 1.17(e) has been timely paid, the finality of the previous Office action has been withdrawn pursuant to 37 CFR 1.114. Applicant's submission filed on 3/27/2009 has been entered.

Response to Amendment

Applicant's amendment of 3/27/2009 does not render the application allowable.

Remarks

Applicant has amended claim 4. Currently claims 1-8 and 12-13 are pending in the application and are considered on their merits below.

Status of Objections and Rejections

All rejections from the previous office action are maintained. Clarifications of all rejections are provided in the action below.

Claim Rejections - 35 USC § 103

2. The following is a quotation of 35 U.S.C. 103(a) which forms the basis for all obviousness rejections set forth in this Office action:

(a) A patent may not be obtained though the invention is not identically disclosed or described as set forth in section 102 of this title, if the differences between the subject matter sought to be patented and the prior art are such that the subject matter as a whole would have been obvious at the time the invention was made to a person having ordinary skill in the art to which said subject matter pertains. Patentability shall not be negated by the manner in which the invention was made.

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3. The factual inquiries set forth in *Graham v. John Deere Co.*, 383 U.S. 1, 148 USPQ 459 (1966), that are applied for establishing a background for determining obviousness under 35 U.S.C. 103(a) are summarized as follows:

1. Determining the scope and contents of the prior art.
2. Ascertaining the differences between the prior art and the claims at issue.
3. Resolving the level of ordinary skill in the pertinent art.
4. Considering objective evidence present in the application indicating obviousness or nonobviousness.

4. This application currently names joint inventors. In considering patentability of the claims under 35 U.S.C. 103(a), the examiner presumes that the subject matter of the various claims was commonly owned at the time any inventions covered therein were made absent any evidence to the contrary. Applicant is advised of the obligation under 37 CFR 1.56 to point out the inventor and invention dates of each claim that was not commonly owned at the time a later invention was made in order for the examiner to consider the applicability of 35 U.S.C. 103(c) and potential 35 U.S.C. 102(e), (f) or (g) prior art under 35 U.S.C. 103(a).

5. Claims 1-8 are rejected under 35 U.S.C. 103(a) as being unpatentable over Sano et al. (US 6180870) in view of Ishihara et al. (US 5021100) and further in view of Nakajima et al. (JP 2000150934).

As to claim 1, Sano et al. show a stacked photovoltaic element (stack type photovoltaic device, depicted in Figure 1) comprising a plurality of unit photovoltaic elements (top cell, 150, middle cell, 140, and bottom cell, 130) each composed of a pin-junction ("pin structures", column 5, line 31), connected to each other in series (as shown in Figure 1). Sano et al. is silent as to a zinc oxide layer being provided between

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two consecutively stacked unit photovoltaic elements. **Examiner note:** Sano provides a light reflecting layer (102/101) adjacent to the substrate (100) and opposite light incidence (top of cell/transparent electrode).

Ishihara et al. disclose a stacked photovoltaic element ("multiple cell photovoltaic device", Figure 1) that contains an upper solar cell (second solar cell, 12) and a lower solar cell (first solar cell, 11) and that are separated by a selective reflection film (ZnO) (8). As Ishihara et al. explain in column 2, lines 42-47, the purpose of the selective reflective film is to reflect short wavelength light which may be absorbed by the upper solar cell (12) and to transmit long wave-length light which is not absorbed by the upper solar cell (12) and may be absorbed by the lower solar cell (first solar cell, 11). Ishihara et al. teach in column 2 lines 47-51 that this increases the photocurrent generated in the upper cell without reducing the current generated in the lower cell "thereby balancing the photocurrents in the respective cells." Ishihara et al. further teach that the material for the selective reflection layer may be zinc oxide (ZnO) in column 4, line 54.

It would have been obvious to one of ordinary skill in the art at the time of the invention to provide the selective reflection layer (instant zinc oxide layer) of Ishihara et al. between each of the photovoltaic elements of Sano et al. (i.e., at the junction in which 150 is the upper cell and 140 is the lower cell, and at the junction in which 140 is the upper cell and 130 is the lower cell) in order to increase the photocurrent generated in the lower cell without reducing the current generated in the upper cell and thereby balance the photocurrents in the respective cells.

What the zinc oxide layer selective reflective layer of Ishihara et al. (and, therefore, the modified device of Sano et al) fails to provide is that the resistivity of the zinc oxide selective reflection layer varies in the direction of its thickness.

However, Nakajima et al. disclose photovoltaic cell (Drawing 1) that contains a zinc oxide diffusion barrier layer (4) with a non-uniform concentration of metallic impurities (e.g., 1-3 wt. % aluminum, paragraph 0013). As Nakajima et al. explain in paragraph 0004, the addition of metallic impurities such as aluminum or gallium to the zinc oxide layer raises the conductivity of this layer and leads to an improved junction between the zinc oxide layer (4) and subsequent photo-electric conversion layers (3) of the device. The concentration of metallic impurities in the zinc oxide layer is chosen to be non-uniform (i.e., greater at the end of the zinc oxide layer that contacts the photo-electric conversion layer than at the opposite end of the zinc oxide layer) so that the said junction may be improved without compromising the light-transmissive properties of the zinc oxide layer (paragraph 0004). Nakajima et al. further teach that this non-uniform concentration may be either composed of “a plurality of layer constitutions having different impurity concentrations” or be a single layer with a “graded” impurity concentration (abstract). Any such graded concentration of metallic impurity along the direction of the thickness of a zinc oxide film would necessarily create a corresponding gradient in the resistivity of said film given that the presence of the metallic impurity increases the conductivity of the zinc oxide (paragraph 0004). **Examiner note:** Nakajima provides a reflective metal layer (5) opposite the incident light side of the cell (bottom/1).

Therefore, it would have been obvious to one of ordinary skill in the art at the time of the invention to provide the non-uniform impurity concentration of Nakajima et al. to the zinc oxide selective reflection layers of the modified device of Sano et al. such that the end of the zinc oxide film with the higher concentration of metallic impurity would be at the junction between the n-layer of 150 and the zinc oxide selective reflection layer separating 150 from 140, and at the junction between the n-layer of 140 and the zinc oxide selective reflection layer separating 140 from 130 in order to improve the junction between the zinc oxide layer and subsequent photo-electric conversion layers of the device without compromising the light-transmissive properties of the zinc oxide layer and as such is clearly within purview of one of ordinary skill in the art.

As to claim 2, applying the impurity concentration of Nakajima et al. to the modified device of Sano et al. as described above would necessarily create a zinc oxide layer with a lower resistivity on the side of the zinc oxide layer that is in contact with the n-layer of each of the upper photovoltaic devices (i.e., 140 and 150).

As to claim 3, applying the graded impurity concentration of Nakajima et al. to the modified device of Sano et al. as described above would necessarily create a continuous decrease in the resistivity of the zinc oxide from the side in contact with the p-layer of the upper photovoltaic device towards a side of the zinc oxide layer in contact with the n-layer of the lower photovoltaic device. This is so because the resistivity is inversely related to the concentration of metallic impurities which, as described above, would continuously increase in the zinc oxide layer from the side in

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contact with the p-layer of the upper photovoltaic device towards a side of the zinc oxide layer in contact with the n-layer of the lower photovoltaic device.

As to claims 4 and 5, one of ordinary skill in the art would tailor the concentration of metallic impurities in the graded impurity concentration of Nakajima et al. provided to the modified device of Sano et al. as needed in order to improve the junction between the zinc oxide layer and the subsequent photo-electric conversion layers of the device as instructed in by Nakajima et al. in paragraph 0005. Although Nakajima et al. do not report the sheet resistance of the layer, it has been shown that a few atomic % of Al-doping of zinc oxide films can give sheet resistances well within the range of claim 4 (i.e., $2 \times 10^2 \Omega\text{cm}$ and $5 \times 10^3 \Omega\text{cm}$) or claim 5 ($5 \times 10^2 \Omega\text{cm}$ and $5 \times 10^3 \Omega\text{cm}$). For this see Figure 1 of Rabadanov et al. (R. A. Rabadanov, M. K. Guseikhanov, I. Sh. Aliev and S. A. Semiletov, "Properties of metal-zinc oxide contacts", *Izvestiya Vysshikh Uchebnykh Zavedenii, Fizika*, 6, 72–75 (1981)).

As to claim 6, Sano et al. state that the i-type layer (113) of the uppermost cell (150) may be composed of amorphous silicon in column 8 lines 6-8. Sano et al. further specify that said amorphous silicon may be a-Si-H in column 8 line 41.

As to claims 7 and 8, Sano et al. state the i-type layer (110) of the middle cell (140) is composed of microcrystalline silicon in column 8, line 9. Since microcrystalline silicon is a form of polycrystalline silicon, the same line indicates that the i-type layer of the middle cell may be composed of polycrystalline silicon.

1. Claims 12 and 13 are rejected under 35 U.S.C. 103(a) as being unpatentable over Ishihara et al. (US Patent 5,021,100) in view of Mahan et al. (US 6, 468,885).

In regard to claim 12 and 13, Ishihara et al. discloses a method for producing a stacked photovoltaic element comprising an intermediate layer/ITO/selective reflective layer (8) between photovoltaic elements each having a pin-junction (3-5) (col.1; lines: 10-28 & col. 3; lines: 18-41 & col. 6; lines: 4-18) as shown in Figure 1, comprising the steps of: stacking a first layer(collectively photovoltaic-12 which is composed of 3-6) mainly composed of ITO (col. 3; lines:34-36) on at least one interface (6) with the photovoltaic element (12) as shown in Figure 1; and stacking a second layer/Photovoltaic (11) composed of (2, 1, 7, 8) mainly composed of zinc oxide (8) (Ishihara et al. also discloses other materials besides ITO for the selective reflection layer-8) (col. 4; lines: 50-57) (12) on direct contact the first layer of photovoltaic elements of p-i-n junction (11 or 12) and in direct contact to form a intermediate layer/middle layer/selective reflective layer (8). However, Ishihara et al. fails to disclose that the second layer is formed at a higher rate than that of the first layer and also the second layer is formed at a higher temperature than the first layer.

Mahan et al. discloses deposition conditions for semiconductor device (col. 1; lines: 33-35) and teaches that the appropriate conditions for depositing silicon film and the hydrogen content of the film appears to be controlled by the temperature of the substrate and the deposition rate, such that the higher the temperature or the lower the deposition rate, the lower the hydrogen content (col. 4; lines: 34-49) and further teaches that the incorporation of hydrogen into the amorphous silicon layer which is usually accomplished during the deposition process it will considerably improve the electrical properties of the individual layers and the device(col. 1; lines: 40-45). It would have

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been obvious to one of ordinary skill in the art at the time of the invention to incorporate higher deposition techniques at lower temperatures as taught by Mahan et al. to the photovoltaic tandem cell of Ishihara et al. in order to control the hydrogen content thereby controlling the properties of the silicon layer of the cell.

Response to Arguments

6. Applicant's arguments filed 3/27/2009 have been fully considered but they are not persuasive:

Applicant argues that "Nakajima does not disclose or teach that 'a resistivity of the zinc oxide layer...near a substrate...is higher than a resistivity of the zinc oxide layer...farther from the substrate.' In fact, it teaches away from the features of claim 1"(pp 3 of Arguments).

The Examiner respectfully disagrees. Sano in view of Ishihara and Nakajima teach the limitations of claim 1. Nakajima teaches the impurity concentration of the layer 4 being higher on the side of layer 3 than layer 5. The Examiner notes that the incidence of light occurs at the bottom of the cell in Nakajima (with a reflective layer 5 at the top of the cell) whereas incident light occurs at the top of the cell in Sano (light reflecting layer 101/102 at the bottom of the cell). One of ordinary skill in the art would appreciate that Sano in view of Nakajima teaches the resistivity near a substrate (Sano, 100) is higher than the resistivity of a ZnO layer farther from the substrate (Sano, 100).

Applicant argues that "...none of Sano, Ishihara, and Nakajima discusses electrical defects leading to decreased shunt resistance, passivation as a treatment of

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such defects, and any difficulty that might arise from a configuration of stacked UPEs” (pp 3 of Arguments).

The Examiner notes that this argument is not commensurate in scope with the claims. The instant claims are not drawn to the electrical defects, shut resistance, or passivation of a UPE. Sano in view of Ishihara and Nakajima render obvious the limitations of the instant claims.

Applicant argues that "...Mahan has nothing to do with the manufacturing of an ITR layer normally composed of ZnO and/or In_2O_3 . Mahan certainly does not discuss why one side...of an ITR layer...should be formed at a lower deposition rate and higher temperature..." (pp 4 of Arguments).

The Examiner respectfully disagrees. Mahan is relied upon to teach the deposition conditions for semiconductor device. Mahan teaches the appropriate conditions for depositing silicon film and the hydrogen content of the film is controlled by the temperature of the substrate and the deposition, such that the higher the temperature or the lower the deposition rate, the lower the hydrogen content. Further, Mahan teaches that the incorporation of H in the amorphous silicon layer considerably improves the properties of the individual layers. It would have been within purview of one of ordinary skill in the art at the time of the invention to control the temperature and rate of deposition during manufacture of the device to control the hydrogen content, and subsequently the electrical properties of the device.

Contact/Correspondence Information

Any inquiry concerning this communication or earlier communications from the examiner should be directed to Shannon Gardner whose telephone number is (571)270-5270. The examiner can normally be reached on Monday to Thursday, 8am-5pm EST.

If attempts to reach the examiner by telephone are unsuccessful, the examiner's supervisor, Alexa Neckel can be reached on 571.272.1446. The fax phone number for the organization where this application or proceeding is assigned is 571-273-8300.

Information regarding the status of an application may be obtained from the Patent Application Information Retrieval (PAIR) system. Status information for published applications may be obtained from either Private PAIR or Public PAIR. Status information for unpublished applications is available through Private PAIR only. For more information about the PAIR system, see <http://pair-direct.uspto.gov>. Should you have questions on access to the Private PAIR system, contact the Electronic Business Center (EBC) at 866-217-9197 (toll-free). If you would like assistance from a USPTO Customer Service Representative or access to the automated information system, call 800-786-9199 (IN USA OR CANADA) or 571-272-1000.

/S. G./
Examiner, Art Unit 1795

/Alexa D. Neckel/
Supervisory Patent Examiner, Art Unit 1795